

**COPEPODA AS INTERMEDIATE HOSTS  
OF DIPHYLLOBOTHRIUM LATUM L.  
IN EUROPEAN FOCI OF INFECTION**

Par ALICJA GUTTOWA

4. REMARKS ON THE CLASSIFICATION OF FIRST INTERMEDIATE HOSTS.

Assuming the criteria of an estimate of plankton crustaceans as the intermediate hosts of tapeworms worked out by MICHAJLOW (1932, 1938), I have established on the basis of the results of experimental investigation, three groups of potential hosts of proceroids *D. latum* among *Copepoda*.

1) Species liable to a high percent of infection. Several minutes after their contact with coracidia the larvae appear in their body cavity. A mass digestion of larvae has not been observed. The development of a proceroid takes about a fortnight. These species are the potential hosts of proceroids *D. latum*. They are able, under natural circumstances, to play the main role in the development cycle of *D. latum*, to an extent allowed by ecological conditions.

2) A second type of hosts is characterized by a lower percent of infection incidence, and the strong effect of the first selective barrier (the activity of the intestinal juice) reduces the intensity of infection. The development of larvae within the body cavity is effected without disturbances. These species are potential auxiliary hosts.

3) A third group of hostes are species only accidentally infected. The larvae die swiftly in their body cavity, or else they develop only up to a certain moment, at which their growth and maturing is checked. That type of host is called accidental by MICHAJLOW (1932) and does not play an important role in the parasite's life cycle.

Finally there remains a large number of species totally resistant to the infection of *D. latum*. They comprise the majority of species such as *Macrocyclops*, *Acanthocyclops*, *Ectocyclops*, *Eucyclops*, *Mesocyclops*, *Tropocyclops*, *Paracyclops*. The above mentioned types of hosts, form with their parasites analogical systems: " parasite — host " (MICHAJLOW, 1959, KISIELEWSKA, 1959) — proper system (Systema obligatorium), auxiliary system (Systema auxiliare), accidental system (Systema accidentale).

2. FIRST INTERMEDIATE HOSTS *D. latum*  
IN EUROPEAN FOCI OF INFECTION.

Experimental research has established that in the *Copepoda* group species of the *Diaptomidae* family and *Cyclopinae* subfamily may be distinguished as hosts of procercoids *D. latum*. The majority of species of the *Diaptomus* kind is easily liable to experimental infection as well in European as in North American foci. Potential hosts in the Baltic zone are : *Eudiaptomus gracilis* (Sars), *Eudiaptomus graciloides* (Lill.), *Edudiaptomus coeruleus vulgaris* (Schmeil) and *Acanthodiaptomus denticornis* (Wierzejski). All these species are characteristic for their features of proper hosts.

The subfamily *Cyclopinae* — nearly all kinds of which are in their youth or maturity, in a greater or lesser degree infested by *D. latum* — deserves special attention. It must, however, be mentioned that, with the exception of Copepodite *Cyclops strenuus strenuus*, the remaining species may fulfil the role of auxiliary or accidental hosts. Such phenomena as a lower percent of incidence or intensity of experimental infection, the infestation of only young specimens (*Cyclops strenuus strenuus*) and the dying out or checked growth of larvae in the body cavity, confirm the lack of mutual adaptation of components of a system. The appearance of such phenomena by the majority of species of the *Cyclops* kind supports the hypothesis that the broad tapeworm of man masters the *Cyclops* kind during the process of adaptation.

The following species of *Cyclops* kind are subject to experimental infection in the Baltic Sea zone :

- Cyclops strenuus strenuus* (Fischer) Kozminski — Copepoda IV, V obligatory host
- Cyclops strenuus strenuus* (Fischer) Kozminski — adult, auxiliary host
- Cyclops lacustris* Sars — auxiliary host
- Cyclops scutifer* Sars — auxiliary host
- Cyclops vicinus* Ulj. — auxiliary host
- Cyclops furcifer* Claus — auxiliary host
- Cyclops insignis* Claus — accidental host

Out of the remaining kinds only some species get infected, assuming mostly the attitude of accidental or at the most auxiliary hosts. It has thus been stated by MICHAJLOW (1963) for the Lake Hausersee in Switzerland, where the following species with the exception of *Eudiaptomus gracilis* are liable to infection :

- Thermocyclops prasinus* (Fischer) at the copepodite stage
- Thermocyclops hyalinus* (Rehberg) at the copepodite stage
- Paracyclops* sp. — at the copepodite stage

*Mesocyclops leuckarti* (Claus) — adult

*Acanthocyclops vernalis* (Fischer) — adult

All these show exclusive characteristics of accidental hosts.

The few investigations concerning infestation in natural conditions provide valuable data to be confronted with the results of experiment. The stating of natural infection is generally a difficult matter on account of the great dissemination of the parasite in its environment, resulting in a very low percent of incidence. My research conducted in the Gulf of Bothnia proved the infection of two *Cyclopoida* species by procercoids *D. latum*. These were *Cyclops strenuus strenuus* in the IV and V copepodite stage and adult forms of *Thermocyclops oithonoides*. Both species manifest a very high percent of infection at the time of a first spring invasion. I haven't stated infection by *Diaptomus gracilis* in the examined lake, which can presumably be explained only by the pelagical character of the existence of this species. The hatching of larvae and their strongest invasion occurs, according to my preliminary investigations, in the littoral of lakes (GUTTOWA, 1963).

The results obtained indicate that the broad tapeworm of man is able to infect many *Copepoda* species in European foci of infection. Should the species of North America and Australia be added here, the list of first potential hosts of tapeworm will be even longer. The specificity of the broad tapeworm in its first development stage is therefore large. This phenomenon allows to conclude that the capabilities of *D. latum* in relation to its first intermediate host — are extensive.

### 3. THE VARIABILITY OF SYSTEMS *D. latum*-Copepoda IN THE BALTIC ZONE.

Investigations concerning the first intermediate hosts of *D. latum* conducted in Poland, on the coasts of the Finnish Gulf in U.S.S.R., on the coasts of the Gulf of Bothnia in Finland and in North and South Norway, have indicated differences in the composition of species of hosts as well as in the degree of infection of particular species in the mentioned geographical regions. And so e.g. in Poland the proper potential host of *D. latum* procercoid is *Eudiaptomus coeruleus vulgaris*, in the region of the Finnish Gulf it is *Eudiaptomus gracilis*, in Norway the most important one is the largely spread *Acanthocyclops denticornis* (GUTTOWA, 1961 a, b).

*Eudiaptomus gracilis* is the obligatory host in the region of the Finnish Gulf (100 % incidence of infection). In Poland and Norway its experimental infection is lower (about 60 % incidence of infection) therefore it may here be ranged in the group of auxiliary hosts.

*Cyclops strenuus strenuus* is infected in Poland and in the Finnish Gulf only at the copepodite stage, whereas in Norway it is liable to infection also at the adult stage.

4. THE INFLUENCE OF EXTERNAL ENVIRONMENT  
ON THE OCCURRENCE OF SYSTEMS *D. latum*-Copepoda.

Experimental investigation carried out on intermediate hosts of the broad tapeworm of man allow to establish a certain sphere of species liable to infection. In natural conditions, however, the role of host is not necessarily performed by the species most liable to infection in the experiment. Ecological factors bring about natural selection causing that among potential hosts (physically suitable to the parasite), the species best connected under given circumstances to the parasite, performs the role of natural host. An example of this are the results of my investigation carried out in Finland. I have namely stated that the hosts of *D. latum* proceroids were the species *Cyclops strenuus strenuus* at the stage IV and V of copepodite and the *Thermocyclops oithonoides*. I haven't noted any cases of infection by *Eudiptomus gracilis* showing characteristics of a proper host in the experiment. *Eudiptomus gracilis* is a pelagical species, therefore in spite of physiological properties enabling infection, it should be in positive conditions excluded from the sphere of the proceroid's natural hosts. It may here be added that the infection of larvae *D. latum* occurs chiefly in the litoral, where human and animal excrements are frequently found, and in conditions suitable to the hatching and development of coracids (light, waving).

How far do ecological factors interfere into the relations "host-parasite" is well illustrated by an example of the system "*Eudiptomus gracilis*-*D. latum*". This copepode is the potential host of the broad tapeworm's proceroid along all of the Baltic Sea Zone, but our research shows that the type of system undergoes a considerable variety in different places of the same zone.

The results of a cross geographical contacting of copepodes with the broad tapeworm's larvae have revealed the existence of a local tie between the host and the parasite. For example *D. latum* from the neighbourhood of the Finnish Gulf forms a proper system with the *Eudiptomus gracilis* coming from the same area, whereas with the *Eudiptomus gracilis* coming from Poland or Norway it will form a system of auxiliary type.

The variability among types of systems depending on geographical and ecological factors leads to a replacing of species of hosts in different areas of the hosts' occurrence. This is illustrated by the extremely differentiated list of first potential hosts of the broad tapeworm in Europe and North America. More and more examples of phenomena of that kind may be found in literature and the phenomenon itself of species substituting one another in the role of hosts in different areas, is an expression of parasitological vicariate.

It seems that the external environment influences most strongly the

*Copepoda*, whereas the parasite adapts itself to certain variations met in the host's organism. The variability of the whole system is the resultant of both the above phenomena. The system "host — parasite" is a biological, very dynamic unit, therefore its examination may be conducted only on the background of well known circumstances of the external environment.

*Department of Parasitology,  
Polish Academy of Sciences  
Warszawa, Pasteura 3.*

#### LITERATURE

- GUTTOWA, A., 1961 a. — Experimental investigations on the Systems « Proceroids of *Diphyllobothrium latum* (L.). — *Copepoda* ». *Acta Paras. Pol.*, **9**, fasc. 25.
- 1961 b. — Potential intermediate hosts (Copepoda) of the broad tapeworm of man *Diphyllobothrium latum* (L.) in Norway. *Nytt Magasin for Zool.*, **10**.
- 1963. — Natural focus of infection of plankton crustaceans with proceroids of *Diphyllobothrium latum* (L.) in Finland. *Acta Paras. Pol.*, **11**, fasc. 10.
- KISIELEWSKA, K., 1959. — Types of Copepoda and *Drepanidotaenia lanceolata* (Bloch) host-parasite Systems established experimentally. *Ibid.*, **7**, fasc. 17.
- MICHAJLOW, Wl., 1932. — Les adaptations graduelles de Copepodes comme premiers hôtes intermédiaires de *Triaenophorus nodulosus* Pall. *Ann. de Paras.*, **10**.
- 1938. — Über die Bedürfnis einer Vereinheitlichung der Vorschungsmethoden, die sich auf die Copepoden als Zwischenwirte der Cestoden beziehen. *Zool. Polon.*, **3**.
- 1963. — Results of experimental Infecting of Copepoda from Hausensee (Switzerland) with the Larvae of *Diphyllobothrium latum* (L.) (Cestoda). *Bull. Acad. Pol. Sciences*, Cl II, **11**, nr. 7.